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Factors Contributing to Uniform Heat Distribution in Retorts

Introduction

With food a vital war material it is especially important that cannery operations should be such that all possibilities of spoilage are eliminated.

One of the most important operations in a cannery is that of retorting, because ideal conditions prior to retorting will not ensure a commercially sterile product if the process is not sufficient to destroy any spoilage organisms which may be present.

Because of several outbreaks of spoilage during the past few years, the problem of retort operation has been considered of sufficient importance to justify an extensive investigation, involving a large number of heat distribution tests in retorts, and a survey of retort equipment and practices at a considerable number of canneries. This investigation has shown that the use of improperly equipped and operated retorts is more widespread than is generally realized, and that this is due mainly to lack of information by the industry as to what constitutes proper retort equipment and operation rather than to neglect of responsibility by operators. In order to supply the needed information, the salient facts developed in these studies, and suggestions for improvement of equipment and operation, are presented in this summary statement.

Insufficient Venting May Cause Spoilage

A number of workers have shown that air may be trapped among the cans within a retort load, producing air pockets, or low temperature spaces, in which the cans do not receive the full cook. Such a condition frequently may be the cause of small amounts of spoilage, which some packers have come to expect, although the cause of this spoilage has been obscure. However, to disregard this spoilage is dangerous, because even small amounts of spoilage due to underprocessing suggest unsatisfactory retort operation, a condition which may develop into serious trouble at any time.

Processes for many non-acid canned foods are suggested in National Canners Association Bulletin 26-L, Fifth Edition (Revised), May, 1942. These processes assume, however, that the retort operations will be such as to ensure that the product is being heated in pure steam at the temperature specified for the length of time recommended. When the heating medium is a mixture of air and steam, due to incomplete removal of air from the retort, the effectiveness of the process is diminished by an amount which depends on the quantity of air present, because the transfer of heat to cans is very much faster from steam than from a steam-air mixture. Also, the value of the process may be decreased by the presence of air pockets, in which low temperatures may persist for a considerable period of time. It is evident, therefore, that all the air must be removed from the retort before starting the process if the full value of the cook is to be realized.

This summary is intended primarily to inform cannery superintendents and retort operators as to what constitutes proper retort equipment and operation according to present experience and knowledge. Additional copies will be sent upon request. For further information on retort venting, inquiries should be sent to the Research Laboratories of the National Canners Association, either in Washington, D. C., or San Francisco. Studies are still in progress.

Unreliability of Temperature-Pressure Agreement

Canners have for many years relied upon a relationship between thermometer and pressure gauge readings—the so-called "temperature-pressure agreement"—as an index of complete air removal. The results of the present investigation have shown, however, that "temperature-pressure agreement" may be very misleading, because the air which is sometimes trapped among the cans in the retort load does not affect the readings of the thermometer or pressure gauge attached to the shell of the retort.

In extreme cases of test runs, pockets of trapped air having temperatures more than 100° F. below that indicated by retort thermometers have been obtained and shown to persist for a period of time sufficient to result in underprocessing, while at the same time there was "agreement" between the retort thermometer and pressure gauge readings. Such results definitely demonstrate the unreliability of temperature-pressure agreement as the sole criterion of uniform heat distribution in a retort load. On the other hand, the *lack* of temperature-pressure agreement is a definite indication of the presence of air in the retort, and venting must always be continued at least until "agreement" is reached. However, the vents should not necessarily be closed as soon as "temperature-pressure agreement" is attained, but should remain open until all the air pockets have been removed from among the cans, which can be determined by heat distribution tests in the retort in question or estimated by comparison of the retort and its equipment with other retorts in which heat distribution tests have been made. Extensive tests have been conducted for the purpose of finding out how large the vents on a retort should be and how long these vents must remain open in order to ensure complete removal of air.

Retort Vents

The term "vent" refers to large valve-controlled openings to be used for the elimination of air from retorts. The ⅛- or ¼-inch pet cocks serve only as bleeders, and are too small to be considered as vents suitable for removal of air during the coming-up period. Vents should be in the opposite side or end of the retort from that at which the steam is admitted. Various arrangements of vents may be used to obtain uniform heat distribution throughout a retort.

Vent valves should be of the gate or plug cock type, preferably quick acting. If globe valves are used, they should be of at least one pipe size larger than the vent pipe.

Factors Influencing Venting Operations

Retorts when fully loaded contain considerable air which must be completely replaced by steam before the process is begun. A vertical retort when fully loaded may still have over 60 per cent of its space occupied by air, and a fully loaded horizontal retort may have 70 to 80 per cent of its space occupied by air. Because of the tendency for air to become trapped among the cans, vent valves should be left wide open until such air has been eliminated.

Proper Equipment and Operation Vital

To ensure complete elimination of air pockets and the attainment of uniform heat distribution during commercial operation, it is necessary to equip retorts with vents proportioned to the size of the retorts and to establish minimum temperatures which must be attained before the vents are closed. These times and temperatures depend upon the venting procedures used with different retorts and upon other factors which may influence steam circulation in the retort. Tests have shown that a retort must be exceptionally well vented to have a coming-up time of less than 5 minutes.

Any statement as to the amount of venting required must presuppose a consideration of the following conditions: Size of retort, type of stacking equipment used, size and location of vent or vents, length of vent discharge pipes, type of valves used on vent pipes, boiler pressure and capacity, distance of retorts from boiler, size of steam header pipe, size of steam inlet pipe, size of steam spreader pipe, number and size of holes in steam spreader, etc. The following are some of the factors influencing heat distribution in retorts and suggestions for retort installation and operation.

Drop in Temperature at Steam-up

The drop in temperature which frequently occurs in a pressure-controlled retort when the bypass is closed and the controllers begin to operate may be caused by the presence of air in the retort at that time.

Stacking of Cans in Retort

For most efficient operation of a retort, cans should be so stacked that the air can be removed rapidly enough to permit a uniform distribution of heat throughout the retort at the time processing temperature is attained. Anything which interferes with the free flow of steam through any part of a retort makes this requirement more difficult to meet.

Trays and Baskets

There are various types of trays, pans, baskets, and gondolas used for holding cans in retorts. Strap-iron or wire equipment is desirable because it permits good steam circulation. Perforated sheet metal equipment as generally used offers more of a baffling effect to the flow of steam than properly constructed strap-iron containers. If perforated sheet metal trays or baskets are used, they should be adequately perforated (at least the equivalent of 1-inch holes on 1½-inch centers, or a wire mesh (about 13 to 16 gauge wire with about ½-inch to 1-inch mesh) should be placed on the bottom to allow for better circulation of steam. This wire mesh on the bottom of the basket is for the purpose of raising the bottom layer of cans sufficiently so that the cans will not hinder steam circulation if placed directly over the holes in the bottom plate.

Arrangement of Cans

In the large baskets used in vertical retorts, or in the gondolas or deep pans sometimes used in horizontal retorts, cans are stacked many layers deep. Under these conditions it is very important that cans be staggered, so that they do not rest directly over one another so as to give a tubular effect. In all deep baskets, a "jumble" method of filling is the most desirable, except in the case of certain products, such as asparagus, which must be processed in a vertical position, or No. 10 cans of spinach, which should be processed in a horizontal position.

Where baskets are stacked several deep, as in vertical retorts, the top layer of cans in each basket should not project above the rim of the basket. If a space is not left between each pair of baskets and one basket rests directly on the layer of cans below it, steam circulation may be hindered considerably. Also, cans carrying the load above are apt to suffer mechanical damage.

Baffle Plates and Dividers

The ordinary perforated baffle plate in the bottom of the retort tends to direct the flow of steam around the baskets rather than up among the cans. It is advisable, therefore, that it be removed. However, if a pressure cooling system, utilizing steam pressure only, without compressed air or injected air, is used, the removal of the baffle plate may introduce difficulties in maintaining the layer of hot water above the cold water used for cooling, with a resultant loss of pressure. Also, it is felt by some packers that the baffle plate prevents discoloration of cans by alkaline compounds carried from the boiler in the steam. It is advised that some means be provided to take care of these possibilities before the baffle plate is removed.

Some canners use separators of various kinds, such as sacks, board, perforated plates, or wire mesh, between cans having different code marks in the same retort load and on top of cans in baskets to prevent them from floating during cooling. Sacks, boards, perforated plates, or similar materials should not be used. Wire mesh or fish nets are recommended.

Steam Supply

The steam supply lines entering the retorts from the header should be as short as possible and sufficiently large—at least 1-inch pipe size for vertical retorts and 1¼-inch pipe size for horizontal retorts. Large steam supply inlets and proportionately large vents promote more rapid air elimination during the come-up time and make possible shorter come-up times.

The holes in the steam spreader should be along the top of the pipe, so that the steam is directed upward into the load and *not down* against the shell.

When a retort has been idle for an hour or longer, the first run thereafter may have poorer heat distribution than when the retort is in more frequent use. It is considered important that the steam line be blown out immediately before use. This can be accomplished by closing the lid of the retort and turning on the steam for a minute or two, or until live steam, free from air or condensate, is flowing from the line.

In plants where the steam is not withdrawn from the supply line fast enough, the steam may contain considerable moisture, and heat distribution in the retorts may be affected. It is suggested that where retorts receive steam through long lines from which there is not rapid withdrawal of steam, the line should be bled or provided with a trap to remove the condensate. It has also been found that the practice of filling the boilers while a cook is "coming up" may cause a similar condition. Such a practice should be avoided.

Partially Filled Retorts

A retort only partially filled with cans contains considerably more air than one with a full load. This must be kept in mind during the coming-up period and the vents must be left open for a sufficient period of time to remove all this air. This usually requires more venting than when the retort is fully loaded.

Recommendations for Retort Venting Systems

The following venting arrangements and cycles of operations have been found by test to give satisfactory temperature distribution. Doubtless other venting procedures may prove equally satisfactory, but it has been shown experimentally that, if the venting arrangement or cycle of operation deviates markedly in the direction of less thorough venting, non-uniform temperature distribution frequently results which is of such magnitude as to be hazardous. Admitting steam at the top of a vertical retort and venting from the bottom has been used to some extent. These hookups, however, are not within the scope of this report.

Conditions vary in different plants, and mbdifications of these recommendations may be necessary to make them practicable in some instances where, with individual hookups, the boiler pressure, boiler capacity, or size of steam inlet pipe to the retort is insufficient to permit reaching the temperature specified within the recommended times.

Vent pipes should not be extended beyond the valve more than necessary, and elbows or restrictions of any sort should be avoided. It is suggested that the extension pipe be of at least one pipe size larger than the valve.

Vertical Retorts

The following suggestions for venting vertical retorts apply only:

I. To retorts not larger than approximately 40 inches diameter by 72 inches high.

II. When the following equipment is used:

1. Strap-iron or adequately perforated metal baskets (at least the equivalent of 1-inch holes on 1½-inch centers).

2. Vents located in or near the top of the retort.

3. Vent valves of the *gate or plug cock type*, preferably quick acting. If globe valves are used, they should be of at least one pipe size larger than the specified vent pipe size.

4. At least a 1-inch, high-pressure steam line into the bottom of the retort and arranged so that steam is directed up into the load of cans.

5. Steam supplied from a boiler in which is carried a pressure of at least 90 pounds per square inch.

III. When the following are not used in the retort:

1. Baffle plates of usual perforated type.

2. Perforated metal or cloth dividers.

3. Perforated metal plates laid on top of cans to prevent floating when cooling.

System A. *Venting through a Single 1½-Inch Overflow Pipe.* Venting of a vertical retort may be accomplished through a 1½-inch overflow pipe if it is connected to the retort within a few inches of the top of the shell and is equipped with a *gate valve*. The overflow pipe should have not more than 6 feet of 1½-inch pipe beyond the valve, and should discharge directly into the atmosphere from the end of the pipe. Elbows and restrictions should be avoided.

Operation: The vent valve should be wide open when steam is turned on, and it should remain wide open for at least 4 minutes after steam is turned on and also until the retort reaches a temperature of at least 218° F.

(Alternative): When the boiler pressure is too low for the above procedure to be workable, the following should be used. The vent valve should be wide open when steam is turned on, and it should remain wide open for at least 5 minutes after steam is turned on and also until the retort reaches a temperature of at least 215° F.

System B. *Venting through a Single 1-Inch Top Vent.* Venting of a vertical retort may be accomplished through a single unrestricted 1-inch vent located in the lid of the retort. This vent should be equipped with a 1-inch *gate valve* and should discharge directly into the atmosphere.

Operation: The vent valve should be wide open when steam is turned on, and it should remain wide open for at least 5 minutes after steam is turned on and also until the retort reaches a temperature of at least 230° F.

Horizontal Retorts

The following suggestions for venting horizontal retorts apply:

I. To retorts 4 to 5 feet in diameter and less than 25 feet in length, except when the length is otherwise specified.

II. When the following equipment is used:

1. Strap-iron or adequately perforated metal trays (at least the equivalent of 1-inch holes on 1½-inch centers).

2. *Gate valve* vents located in the top of the retort and discharging directly into the atmosphere without extension pipes. If globe valves are used, they should be of at least one pipe size larger than the specified vent pipe size.

3. A steam spreader along the bottom of the retort and with holes in the top of the spreader so that the steam is directed up into the load of cans.

4. At least a 1¼-inch, high-pressure steam line into the bottom of the retort.

5. Steam supplied from a boiler in which is carried a pressure of at least 90 pounds per square inch.

System No. 1. *Venting through the Water Spreader.* Venting of a horizontal retort may be accomplished through the water spreader pipe located along the top inside the retort. The water spreader must be of at least 1½-inch pipe size, with an inlet of at least 2-inch pipe size for retorts up to 15 feet in length. For retorts over 15 feet in length, the water spreader must be of at least 2-inch pipe size, with an inlet of at least 2½-inch pipe size. The inlet pipe must be within 3 feet of the center of the retort, lengthwise. If it is further from the center than this, the spreader pipe must be of the same size as the inlet. The vent pipe and valve should be of the same size as the water inlet pipe and should be connected to the water inlet pipe as near to the retort shell as possible. A *gate valve* should be used on the vent pipe.

The water spreader should have holes not less than 3/16 inch in diameter, distributed uniformly along the length of the spreader pipe. The number of holes per linear foot should be approximately as follows:

Diameter of hole	Number of holes per linear foot
3/16 inch	14 to 18
7/32 "	11 to 13
1/4 "	8 to 10

Operation: The water spreader vent valve should be wide open when steam is turned on, and it should remain wide open for at least 5 minutes after steam is turned on and also until the retort reaches a temperature of at least 225° F.

(Alternative): If the boiler pressure is too low for the retort to reach 225° F. within 5 minutes, the vents should remain wide open for at least 7 minutes after steam is turned on and also until the retort reaches a temperature of at least 220° F.

System No. 2. *Venting through the Drain in Conjunction with the Water Spreader.* The water spreader installations for this system should be the same as those described for the water spreader system No. 1.

The drain should be of not less than 3-inch pipe size for retorts up to 15 feet in length and should be of not less than 4-inch pipe size for longer retorts. The drain should be equipped with a *gate valve* of the same size as the drain pipe.

The drain should have an unrestricted discharge from the valve to the atmosphere.

Operation: The drain valve should be wide open when steam is turned on,

and should remain wide open for at least 2 minutes after steam is turned on and also until the retort reaches a temperature of at least 212° F.

The water spreader vent valve should be wide open when steam is turned on, and should remain wide open for at least 5 minutes after steam is turned on and also until the retort reaches a temperature of at least 218° F.

System No. 3. ***Venting through a Single 2½-Inch Top Center Vent.*** (This procedure is not adequate for retorts more than 15 feet in length.) Venting of a horizontal retort may be accomplished through a single 2½-inch unrestricted vent located at about the top of the shell and within 2 feet of the center, lengthwise.

The 2½-inch vent pipe should be equipped with a 2½-inch *gate valve* and should discharge directly into the atmosphere.

Operation: The vent valve should be wide open when steam is turned on, and should remain wide open for at least 4 minutes after steam is turned on and also until the retort reaches a temperature of at least 220° F.

System No. 4. ***Venting a Retort through the Drain in Conjunction with a Single 1½-Inch Top Center Vent.*** (This procedure is not adequate for retorts more than 15 feet in length.) Venting of a horizontal retort may be accomplished through the drain when used in conjunction with a single 1½-inch unrestricted vent located at about the top of the retort and within 2 feet of the center, lengthwise.

The 1½-inch vent pipe should be equipped with a 1½-inch *gate valve* and should discharge directly into the atmosphere.

The drain should be of not less than 4-inch pipe size and should be equipped with a *gate valve* of the same size as the drain pipe.

The drain should have an unrestricted discharge from the valve to the atmosphere.

Operation: The drain valve should be wide open when steam is turned on and should remain wide open for at least 2 minutes after steam is turned on and also until the retort reaches a temperature of at least 212° F.

The 1½-inch top center vent valve should be wide open when steam is turned on, and it should remain wide open for at least 5 minutes after steam is turned on and also until the retort reaches a temperature of at least 220° F.

System No. 5. ***Venting through Multiple 1-Inch Vents Discharging Directly into the Atmosphere.*** Venting of a horizontal retort may be accomplished through multiple unrestricted 1-inch vents approximately uniformly distributed along the top of the retort with one vent for every 5 feet of retort length, or fraction thereof, the vents being so located that there is one within about 2½ feet of each end of the retort, so as to be over the center of the end trucks.

These vent pipes should be not over 6 inches in length and should be equipped with 1-inch *gate valves* discharging directly into the atmosphere.

Operation: The 1-inch vent valves should all be wide open when steam is turned on, and they should remain wide open for at least 5 minutes after steam is turned on and also until the retort reaches a temperature of at least 225° F.

(Alternative): If the boiler capacity in a plant is such that 225° F. is not reached within 5 minutes, the vents may be closed when a retort temperature of 220° F. has been reached, provided the vents have been wide open for at least 7 minutes since steam was turned on.

System No. 6. ***Venting through the Drain in Conjunction with Multiple 1-Inch Vents.*** The multiple 1-inch vent installations for this venting system are the same as those described under System No. 5 for multiple 1-inch vents.

The drain should be of not less than 3-inch pipe size for retorts up to 15 feet in length and of not less than 4-inch pipe size for longer retorts, and should be equipped with a *gate valve* of the same size as the drain pipe.

The drain should have an unrestricted discharge from the valve to the atmosphere.

Operation: The drain valve should be wide open when steam is turned on, and it should remain wide open for at least 2 minutes after steam is turned on and also until the retort reaches a temperature of at least 212° F.

The 1-inch vent valves should all be wide open when steam is turned on, and they should remain wide open for at least 4 minutes after steam is turned on and also until the retort reaches a temperature of at least 220° F.

System No. 7. ***Venting through Multiple 1-Inch Vents Discharging through a Manifold.*** Venting of a horizontal retort may be accomplished through multiple unrestricted 1-inch vents not over 6 inches in length and discharging into a manifold. The vent pipes should be approximately uniformly distributed along the top of the retort, with one for every 5 feet of retort length, or fraction thereof, the vents being so located that there is one within about 2½ feet of each end of the retort, so as to be over the center of the end trucks.

The manifold should discharge through a *gate valve* of at least 2½-inch size on retorts up to 15 feet in length and of at least 3-inch size on longer retorts, and the manifold pipe in every case should be at least as large as the discharge valve.

Operation: The manifold vent valve should be wide open when steam is turned on and should remain wide open for at least 6 minutes after steam is turned on and also until the retort reaches a temperature of at least 225° F.

(Alternative): If the boiler pressure in the plant is such that 225° F. is not reached within 6 minutes, the vent valve may be closed when a retort temperature of 220° F. has been reached, provided the vent has been wide open for at least 8 minutes since steam was turned on.

System No. 8. ***Venting through the Drain in Conjunction with Multiple 1-Inch Vents Discharging through a Manifold.*** The 1-inch manifolded vent installations should be the same as those described under System No. 7 for the manifold venting system.

The drain should be of at least 3-inch pipe size for retorts up to 15 feet in length and of at least 4-inch pipe size for longer retorts, and should be equipped with a *gate valve* of the same size as the drain pipe.

The drain should have an unrestricted discharge from the valve to the atmosphere.

Operation: The drain valve should be wide open when steam is turned on, and it should remain wide open for at least 3 minutes after steam is turned on and also until the retort reaches a temperature of at least 212° F.

The manifold vent valve should be wide open when steam is turned on, and it should remain wide open for at least 5 minutes after steam is turned on and also until the retort reaches a temperature of at least 220° F.